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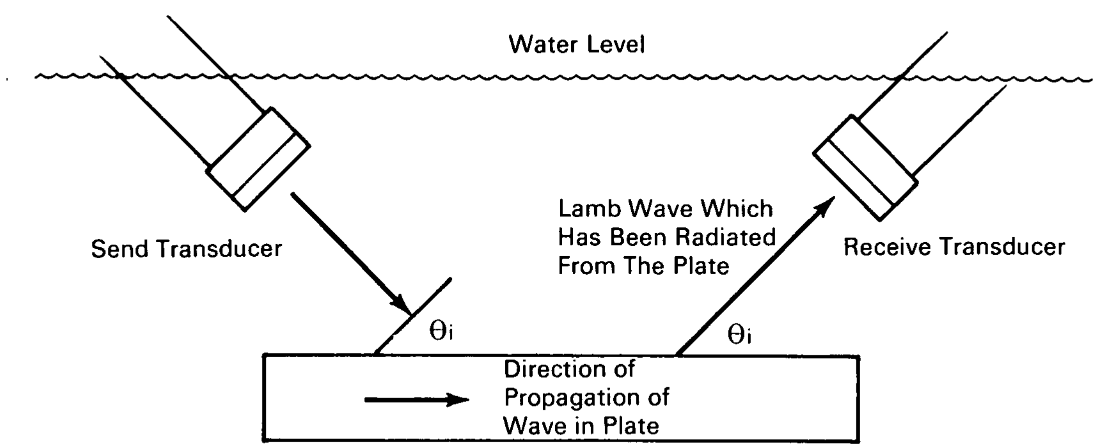
Lamb Waves Increase Sensitivity in Nondestructive Testing



The problem:

To obtain greater sensitivity and resolution in the nondestructive inspection of thin specimens for cracks and small defects. With the conventional method, using shear waves, many extremely small or very shallow defects were undetectable.

The solution:

Lamb waves offer improved sensitivity and resolution for the detection of small defects in thin plates and small diameter, thin-walled tubing. This improvement over shear waves applies to both longitudinal and transverse flaws in the specimens.

How it's done:

Lamb waves consist of an infinite number of modes of vibration that can be generated in elastic materials. In a given material, each Lamb wave mode has a different velocity of propagation (phase velocity), dependent upon the thickness of the specimen, the wave frequency, the order of the mode and the material in which the wave is generated. Thin materials are the most suitable for the generation and detection of Lamb waves at ultrasonic frequencies.

Lamb waves can be generated in thin materials (plates or tubing) in the manner shown in the figure: A longitudinal sound wave with a speed V_L is sent through a coupling medium, usually water, such that it strikes the plate specimen at angle Θ_i. The speed at which the line of contact of any wave front runs along the surface of the plate is

$$V_a = V_L/\sin \Theta_i$$

If the speed V_a equals the phase velocity of a Lamb wave mode, the mode is generated in the plate by a resonance process. The wave travels down the plate and radiates from it, along the entire length, with an exit angle Θ_E equal to Θ_i. A receiving transducer, positioned at angle Θ_e, will detect this energy, which can be amplified and displayed.

Once a Lamb wave is generated, it will continue to travel down the plate, attenuated but otherwise undisturbed, until it reaches a discontinuity such as the edge of the plate or a flaw. A flaw or crack is easily

(continued overleaf)

detectable because at that point the fd (phase velocity frequency thickness) product is not satisfied and the Lamb wave mode does not appear. A receiver transducer aimed at this flaw area thus indicates the presence of the flaw by the absence of a signal.

A flaw can also be detected using one transducer as both sender and receiver. In this configuration, no signal is received until the Lamb wave reaches a discontinuity. The mode is, in part, reflected from the discontinuity and travels back along the plate. It also is radiated from the plate at an exit angle Θ_E equal to Θ_i, and thus can be detected by the same transducer that was used to generate it.

The technique itself is identical to that used for shear wave testing, although a completely different stress wave is involved. Using the one-transducer method and a simulated crack, numerous experiments were run which illustrated that greater sensitivity and resolution for nondestructive testing can be obtained with Lamb waves.

Notes:

1. The main limitation of this technique is the necessary critical alignment of the equipment.
2. Complete details are contained in *Lamb Waves: Their Use in Nondestructive Testing*, by R. A. DiNovi, ANL-6630, March 1963; and in *Status Report on Lamb Waves*, by the same author, ANL-6329, March 1962; both reports from Argonne National Laboratory, Argonne, Illinois. The reports are available from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Va. 22151. Price: $3.00 each (microfiche, $0.65).
3. Inquiries concerning this innovation may be directed to:

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   Argonne National Laboratory
   9700 South Cass Avenue
   Argonne, Illinois 60439
   Reference: B67-10605

Source: R. DiNovi
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Patent status:

Inquiries about obtaining rights for commercial use of this innovation may be made to:

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